Do people who feel more connected to nature do more to protect it?
A meta-analysis

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Abstract

Nature connection, defined as a subjective sense of oneness with nature, is one psychological variable that promotes pro-environmental behaviour (Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2009). This meta-analysis reviews correlational and experimental evidence for this relationship. Results in the correlational analysis show a strong association between nature connection and pro-environmental behaviours ($r = .41$), which was significant for various operationalizations of nature connection and private sphere and public sphere pro-environmental behaviours. Unlike in the correlational data, there was evidence of publication bias when meta-analyzing experimental studies. By including unpublished studies in the meta-analysis, I corrected for this bias and found a small but significant causal effect of nature connection on pro-environmental behaviour ($d = .25$). I discuss discrepancies between how nature connection is measured and manipulated, and how future studies can better examine the processes by which nature connection causes pro-environmental behaviour.

Keywords: nature connection; pro-environmental behaviour; meta-analysis

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Chapter 1.

Introduction

The actions of humans have serious consequences for the environment and human systems. For instance, experts in climate science overwhelmingly agree that humans have caused climate change, which will have devastating impacts on the earth (Anderegg, Prall, Harold, & Schneider, 2010; Doran & Zimmerman, 2009). Therefore, addressing environmental crises, such as climate change, involves changing human behaviour. Recently, psychologists have demonstrated that nature connection, in which people experience a sense of "oneness" with nature, predicts pro-environmental behaviour (Mayer & Frantz, 2004; Schultz, 2001; Perkins, 2010). Although this is a relatively new area of research, interest in nature connection has been increasing among psychologists interested in issues of environmental sustainability, and a sizeable literature exists on nature connection and pro-environmental behaviour. Many researchers have found positive associations between nature connection and pro-environmental behaviour (Clayton, 2003; Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2009; Tam 2013), and in a few experimental studies, evidence that that nature connection causes pro-environmental actions (Davis, Green, & Reed, 2009; Zelenski, Dopko, & Capaldi, 2015). However, the strength of the relationship between nature connection and pro-environmental behaviour cannot be easily assessed from single studies or narrative reviews. Furthermore, there may be biases in what effects are reported in the literature as compared to unpublished data. Such gaps can be addressed through meta-analytic techniques that synthesize the evidence for the relationship between nature connection and pro-environmental behaviour. To date, no meta-analysis on nature connection and pro-environmental behaviour exists; thus, I addressed this gap by conducting a meta-analysis of studies that have examined the relationship between nature connection and pro-environmental behaviour.

1.1. Conceptualizations and Operationalizations of Nature Connection

I will describe how nature connection is defined for the purposes of this meta-analysis and review some of the most common operationalizations of nature connection used in the literature. Broadly, nature connection refers to a subjective sense of "oneness" with nature (Capaldi, Dopko, & Zelenski, 2014; Mayer & Frantz, 2004). This sense of oneness with nature comes from incorporating nature into one's self-definition. For example, the Inclusion of Nature in the Self scale (INS) attempts to measure overlap between an individual's self-concept and the natural world. The INS consists of sets of two circles labelled "self" and "nature" that increasingly overlap, and participants choose which set of circles best represents their perceived relationship with nature. Schultz's INS measure was adapted from close relationships and intergroup relations research used to measure feeling of oneness with another person or group (Aron, Aron, & Smollan, 1992; Tropp & Wright, 2001). Similarly, another early and influential measure of nature connection, the Connection to Nature Scale (CNS), is a fourteen-item questionnaire that consists of statements such as, "I think of the natural world as a community to which I belong" (Mayer & Frantz, 2004).

Early research on nature connection grew out of the biophilia hypothesis, which states that humans experience positive emotions when surrounded by nature, such as awe and wonder, resulting from the experience of being part of a much larger whole (Fromm, 1964 as cited by Perkins, 2010; Kellert & Wilson, 1993; Wilson, 1984). As such, measures of positive emotions felt in nature attempt to capture the affective experience of being at one with nature (Kals, Schumacher, & Montada, 1999; Perkins, 2010). Other researchers have incorporated affective and cognitive aspects of connection to nature in multi-faceted measures of nature connection (Clayton, 2003; Nisbet et al., 2009). Nisbet and colleagues (2009) developed the "Nature Relatedness scale" (NR) to capture love for nature, experiences within nature, and a cognitive understanding and appreciation of being connected to the environment and all living things (Nisbet et al., 2009). Similarly, Clayton (2003) views nature connection as a form of identity that can manifest as feelings of being one with nature and in attitudes towards environmental issues and movements.

All the operationalizations of nature connection discussed thus far have measured explicit affect and cognitions with self-report questionnaires. However, Schultz, Shriver, Tabanico, and Khazian (2004) adapted the implicit association test paradigm (IAT) to measure nature connection. The IAT tests participants' reaction times as a measure of whether participants automatically associate natural environments, rather than urban or built environments, with the self (Schultz et al., 2004). The IAT correlates with explicit measures of nature connection (Tam 2013).

Despite some small differences in how nature connection is conceptualized, measures of nature connection are very similar, and attempt to capture the extent to which individuals' incorporate nature into their sense of self. Furthermore, the majority of nature connection measures perform similarly to one another and have similar relationships with pro-environmental outcomes (Capaldi et al., 2014; Restall & Conrad, 2015; Tam, 2013b). Thus, there is good reason to believe that these operationalizations of nature connection are tapping into the same psychological construct. However, researchers have also reported some variation between measures. Tam (2013) found evidence that multi-dimensional measures of nature connection, such as the Nature Relatedness scale and the Environmental Identity scale, had stronger correlations with pro-environmental behaviours than other nature connection measures. Some researchers have also reported stronger correlations between their own nature connection measures and pro-environmental behaviours compared to previously existing nature connection measures (Davis, Le, & Coy, 2011; Mayer & Frantz, 2004).

1.2. Nature Connection and Pro-Environmental Behaviour

A great deal of research on social identity (Tajfel & Turner, 1979; Turner, Hogg, Oakes, Reicher, & Wetherell, 1987) and individual self-concept (Baumeister, 1999) suggests that self-definition has an important influence on attitudes, goals and behaviour (Sedikides, Gaertner, & O'Mara, 2011). Therefore, incorporating nature into one's self-definition should lead one to readily consider the impact on the natural environment when formulating goals and acting. If people feel a sense of oneness with nature, then they may view threats to the natural world as more serious than people who do not feel connected (Schmitt, Droogendyk, & Payne, 2014), and want to take action to mitigate those threats (Schmitt, Aknin, Axsen, & Shwom, 2018). Furthermore, viewing nature as an aspect of oneself or of a group that one belongs to might also result in one seeing

nature as intrinsically valuable—valuable in and of itself rather than for any resources or benefits it might provide (Mayer & Frantz, 2004; Schultz, 2001; Stern, Dietz, Abel, Guagnano, & Kalof, 1999; Stern, 2000). Thus, whether people experience a sense of "oneness" with nature at an individual level or as a feeling of belonging to nature as a community, incorporating nature into one's self-definition is likely to lead to pro-environmental behaviour.

Recent narrative reviews of the nature connection literature have concluded that nature connection is linked to pro-environmental behaviour (Frantz & Mayer, 2014; Restall & Conrad, 2015). Researchers who initially developed and tested measures of nature connection found significant positive correlations with pro-environmental behaviour (Clayton, 2003; Kals et al.,1999; Mayer & Frantz, 2004; Nisbet et al., 2009; Perkins, 2010; Schultz, 2001; Schultz et al., 2004). Such findings have been replicated in later studies by different researchers with different measures (Geng, Xu, Ye, Zhou, & Zhou, 2015; Olivos & Aragonés, 2013; Tam, 2013). The majority of these correlational studies are cross-sectional in nature; very few have used a longitudinal design (but see Unanue, Vignoles, Dittmar, & Vansteenkiste, 2016; Veijalainen & Clayton, 2013). Longitudinal research has shown that nature connection measured at baseline is associated with subsequent pro-environmental behaviour even when controlling for baseline pro-environmental behaviour (Unanue et al., 2016). However, at least one longitudinal study has found null effects (Veijalainen & Clayton, 2013).

Correlational studies are unable to provide evidence for whether nature connection causes pro-environmental action. The causal direction in this relationship could arguably be in the other direction, whereby doing things to benefit the environment causes individuals to feel more connected to nature. Several researchers have attempted to experimentally manipulate nature connection to determine its effect on pro-environmental behaviour. For example, Davis and colleagues (2009) randomly assigned participants to answer questions about how they felt connected to nature or did not feel connected to nature; participants in the connection to nature condition were more likely than participants in the control condition to report pro-environmental behavioural intentions and to volunteer for conservation efforts (Davis et al., 2009). In another study, Zelenski and colleagues (2015) assigned participants to view photos and documentaries of nature or urban environments; those in the nature condition were more likely than those in the urban condition to show restraint in resource consumption. However, in a

similar study, Scott (2010) did not find significant differences in pro-environmental behaviour between participants who viewed images of nature and participants who had viewed abstract art.

1.3. The Current Study

I conducted two meta-analyses, one using cross-sectional correlational data examining an association between nature connection and pro-environmental behaviour, and one using experimental data testing the effect of nature connection on pro-environmental behaviour.

1.3.1. Correlational Meta-Analysis

Given the sheer number of positive relationships between nature connection and PEB that have been reported in the existing literature, it was highly likely that the meta-analysis of correlational data would confirm the existence of a positive relationship. Thus, a more important contribution of the correlational meta-analysis was to determine the strength of the relationship. There is variation in the reported strength of the association between nature connection and pro-environmental behaviour. Furthermore, some studies have occasionally found negative or non-significant correlations between nature connection and pro-environmental behaviour (Beery & Wolf-Watz, 2014; Hedlund-de Witt, de Boer, & Boersema, 2014). Estimating the strength of a relationship is difficult to do precisely in a narrative review, and thus requires a quantitative method that a meta-analysis provides. Furthermore, knowing the strength of the relationship could potentially be useful to policymakers and those designing interventions aimed at increasing pro-environmental behaviour, as it will provide a comparison between nature connection and other predictors of pro-environmental action that have been examined in past meta-analyses (Bamberg & Möser, 2007). In their review, Restall and Conrad (2015) noted a lack of research that could speak to practical applications that a relationship between nature connection and pro-environmental behaviours might have on policy and interventions aimed at environmental management.

Examining Different Operationalizations of Nature Connection

I examined the relationship between nature connection and pro-environmental behaviour separately for each measure of nature connection (e.g., Nature Relatedness,

Inclusion of Nature in the Self). By examining each measure separately, I could determine if each conceptualization was related to PEB, and how strongly. If results differ depending on the measure of nature connection used, it might shed light on the psychological process by which nature connection promotes pro-environmental action.

Examining Different Types of Behaviour

The majority of nature connection studies measure pro-environmental behaviour by having participants report their own behaviour through questionnaires. However, a recent meta-analysis by Kormos and Gifford (2014) found that participants tend to overestimate their pro-environmental behaviour on self-report measures and thus measuring pro-environmental behaviour through direct observation may more accurately capture behavioural tendencies. Therefore, one goal of this meta-analysis was to separately examine the relationship between nature connection and pro-environmental behaviours based on self-reported versus observed behaviours.

Additionally, researchers have examined the association between nature connection and different types of pro-environmental actions. Private sphere behaviours are aimed at reducing one's own environmental impact (e.g., recycling, transportation, or personal energy use), and public sphere behaviours are aimed at reducing collective impact on the environment (e.g., protection of local areas such as parks or oceans, political actions aimed at affecting environmental policies or creating social change). Some literature on nature connection and pro-environmental behaviours has examined private sphere behaviours concerning attempts to reduce one's consumption and to adopt sustainable lifestyle practices (Clayton et al., 2016). However, given the necessity for widespread societal change to effectively mitigate climate change and other environmental problems, some researchers have attempted to understand the psychological factors driving public sphere behaviours. Thus, I examined whether nature connection is associated with private sphere and public sphere behaviours.

Publication Bias

The correlational and experimental literature reviewed thus far only includes data that has been published; thus, there is a possibility of other studies finding null effects that have not been published—a "file drawer effect" (Fanelli, 2010). This meta-analysis addressed the potential of publication bias by including unpublished studies, and

comparing whether unpublished studies produced smaller effect sizes than published studies. Although narrative reviews of correlational literature suggest that there is a strong association between nature connection and pro-environmental behaviour (Frantz & Mayer, 2014), if many unpublished studies with null findings exists, this association may be weaker than previously suggested. Furthermore, given the smaller literature examining the causal relationship between nature connection and pro-environmental behaviour, the number of unpublished studies finding null effects could influence whether we see evidence of a significant causal relationship. In the correlational and experimental meta-analyses, I compared the results observed in published and unpublished data. As previous qualitative reviews of the literature have not included unpublished data or tested the file-drawer-effect, this meta-analysis represents an important contribution to understanding whether effects reported in this literature may be biased.

Generalizability

In their review of nature connection literature, Restall and Conrad (2015) concluded that the generalizability of findings was limited by the location that studies had been conducted. Specifically, nature connection and pro-environmental behaviour has been primarily examined in North America, Western Europe, and Australia. Furthermore, psychologists often recruit university students as study participants; however, some researchers have turned to the broader community to recruit samples that are more diverse. To address these issues, I examined differences in study populations to test whether variations in sample demographics moderate the relationship between nature connection and pro-environmental behaviour. I examined age, gender, ethnicity, geographical location, and university versus community sample as potential moderators. In examining differences across samples, this study may provide evidence for generalizability of the relationship between nature connection and pro-environmental behaviour across populations.

1.3.2. Experimental Meta-Analysis

Although evidence for a positive correlation between nature connection and pro-environmental behaviour seems clear, the evidence for a causal effect of nature connection on PEB is a less conclusive. Only small number of experimental studies

exist and results have been inconsistent. Some published studies find that nature connection has a significant impact on pro-environmental behaviour (Davis et al., 2009; Zelenski et al., 2015), however some do not find significant effects (Scott, 2010). Others have reported difficulty in successfully manipulating nature connection (Arendt & Matthes, 2014; Davis et al., 2009; Nisbet & Zelenski, 2013; Zelenski et al., 2015).

For the experimental meta-analysis, my purpose was to determine whether sufficient evidence exists to suggest that nature connection causes pro-environmental behaviour. As in the correlational meta-analysis, I compared published and unpublished data. Since fewer experimental studies have been done, correcting for potential publication bias could substantially change the interpretation of published findings. Additionally, given reported difficulty in manipulating nature connection, I examined evidence of success in manipulating nature connection and how this moderated the relationship between nature connection and pro-environmental behaviour. Finally, as in the correlational analysis, I conducted additional analyses, separately examining self-report, observed, private sphere and public sphere behaviours.

Chapter 2.

Methodology

The following section details the general methods used in the correlational and experimental meta-analyses. Methods specific to each meta-analysis will be described in separate sections.

2.1. Data Collection

2.1.1. Inclusion Criteria

To be included in this meta-analysis, correlational studies had to have at least one measure of nature connection, one measure of pro-environmental behaviour, and a report on the relationship between these two variables. Studies examining causal evidence (i.e., experimental) had to have manipulated nature connection with a control or comparison group and measured pro-environmental behaviour as an outcome. If the information necessary to calculate the effect size was not reported, I contacted authors for additional information.

To be included, the measure of nature connection had to fit the following conceptual definition: nature connection is the subjective sense of "oneness" with nature, where "oneness" refers to overlap between nature and the self. This included measures such as inclusion of nature in one's self-concept (Schultz, 2001), or the idea that the natural world is a community to which one belongs (Mayer & Frantz, 2004). However, this definition does not include measures that exclusively focus on spending time in nature or one's identification as someone who engages in environmentally friendly behaviours (e.g., van der Werff, Steg, & Keizer, 2013). Nor does the inclusion criteria for nature connection include identification with environmental activism, or identification as an environmentalist. Although the Environmental Identity scale includes items that measure identification with activists and environmentalism, it also includes items measuring a sense of 'oneness' with the natural world (Clayton, 2003) that fall within the conceptual definition for this meta-analysis. For experimental data, I examined whether studies manipulated nature connection. To be included, experimental studies must have

had two conditions, one in which participants were exposed to nature or primed with nature connection, and a control condition in which participants were not exposed to nature.

For the purposes of inclusion, I defined pro-environmental behaviours as actions that the actor would likely perceive to benefit the environment, rather than trying to define PEBs in terms of actual environmental impact. Pro-environmental behaviour may include individual lifestyle changes, reduction in consumption, participation in environmental activism on behalf of the environment, and voting for pro-environmental policies or candidates. Measures of behaviour may include self-report surveys or actual behaviour observed and recorded during a study. To avoid confounding behaviour with attitudes, I did not include studies that combined behavioural measures into a single scale with items measuring attitudes, beliefs, or values about pro-environmental behaviour.

2.1.2. Identifying Studies

Between September and October of 2016, I searched the online databases PsycInfo and Web of Science to locate records of published studies, and searched ProQuest Digital Dissertations to locate records of unpublished studies (i.e., dissertations and theses). The search included titles, abstracts, and key words that contained terms for nature connection and pro-environmental behaviour (see Appendix A for list of search terms).[1] In addition, a call for unpublished data was sent to prominent researchers in the field on forum and mailing listservs for the Environmental Section of the Canadian Psychological Association, the European Association of Social Psychology, and the Society for Personality and Social Psychology in August of 2016. Additional records of published studies were obtained from the reference sections of the articles gathered from the initial search.

A total of 195 records (i.e., journal articles, unpublished dissertations, unpublished manuscripts and unpublished data) relating to nature connection and pro-environmental behaviour were obtained through online database searches, callouts, and

[1] Full text searches were omitted from the dissertation database, as these produced many unrelated results (e.g., dissertations that only mentioned nature connection or pro-environmental behaviour in passing or in literature review without testing these variables).

contacting individual researchers. Of these 195 records, 50 were determined to be duplicates.[2] An additional 72 articles were screened out because they did not meet inclusion criteria: twenty-six did not measure pro-environmental behaviour, twenty-three did not measure or manipulate nature connection, twelve were review papers or reported only qualitative data, six did not report the relationship between nature connection and pro-environmental behaviour, and five did not report the necessary information to calculate the effect size of the relationship between nature connection and pro-environmental behaviour. The remaining 73 records were included in the meta-analysis, which represented results from 85 studies. Of these, 71 were included in the correlational meta-analysis and 14 were included in the experimental meta-analysis.

2.1.3. Data Analysis Model

When considering data in a meta-analysis, one can adopt a fixed-effects model or a random-effects model. A fixed-effects model assumes that the results of each study are estimates of a single effect size within the population, and that any variation between studies is due to subject sampling errors within studies (Borenstein, Hedges, Higgins, & Rothstein, 2009; Lipsey & Wilson, 2001). In contrast, a random effects model assumes that differences between studies go beyond sampling errors, and may include differences in method and procedure (Lipsey & Wilson, 2001). As such, a meta-analysis using a random-effects model treats the results of studies as a distribution of effects rather than an estimate of a single effect, and estimates the mean of this distribution (Borenstein et al., 2009). For the correlational and causal meta-analyses, I chose a random effects model. In general, the random effects model is better suited for meta-analyses on published literature, rather than multiple studies collected by a single lab or researcher, given the greater potential that variation between studies is due to factors other sampling biases (Borenstein et al., 2009; Lipsey & Wilson, 2001).

[2] Duplicates took the form of the same article or manuscript identified using two different search engines (or receiving one from a contacted researcher after having already identified it through a search engine). In these cases, the duplicates were obvious, as the manuscripts or articles in question were identical. In two cases, duplicates were published articles based on data from unpublished dissertations. In both cases, I contacted the dissertation author who confirmed the published and unpublished studies were the same.

Chapter 3.

Correlational Meta-Analysis

3.1. Methods

The statistic used to measure correlational relationships in this meta-analysis is the Pearson correlation coefficient, r. In one case, associations were reported between a dichotomous pro-environmental behaviour variable and a continuous nature connection scale using t-tests (Nisbet et al., 2009). These t statistic results were converted to r for the purposes of inclusion in this meta-analysis. For data analysis, I transformed the Pearson's correlation coefficient r reported in each study to a Fischer's z score (Zr). Effect sizes were weighted by the inverse variance of the correlation coefficient, r. Thus, effect sizes with less variance (because of larger sample sizes) are weighted more in the estimates the effect size.

Meta-analysis techniques operate under the assumption that effect sizes come from independent samples (Hunter & Schmidt, 1990). However, some study samples included in the correlational meta-analysis used multiple measures of nature connection or pro-environmental behaviour, resulting in multiple correlational effect sizes from the same study (e.g., a study that includes a correlation between a single measure of nature connection and two or more different measures of pro-environmental behaviour). Thus, for my main analysis, I created a set of independent effect sizes by calculating a composite (i.e., average) effect size for each sample.

3.1.1. Coding Procedure

Three undergraduate research assistants and I coded the correlational effect sizes (see Appendix B for detailed coding instructions). Inter-rater agreement between the research assistants and my primary coding ranged between 78%-100% with an

average of 89%.[3] I resolved coding discrepancies by double-checking details in articles and comparing notes made by each coder.

Nature Connection

Correlational studies were coded based on the types of nature connection measures included. These nature connection measures were categorized based on five commonly used instruments: the Connection to Nature Scale (Mayer & Frantz, 2004), the Inclusion of the Other in the Self scale (Schultz, 2001), the Environmental Identity scale (Clayton, 2003), the Nature Relatedness scale (Nisbet et al., 2009), and the Implicit Association Test (Schultz et al., 2004).[4] In addition to these five measures, an additional category was created for measures of emotional nature connection. Studies in this category included a measure of nature connection where most of the items measure participants' self-reports of positive emotions that they experience while in nature. Measures of emotional nature connection include the Emotional Affinity Toward Nature Scale (Kals et al., 1999) and the Love and Care for Nature scale (Perkins, 2010). Finally, studies that used measures of nature connection that did not fit into any of the previously listed categories were coded as 'other.'

Pro-Environmental Behaviour

Studies were coded as using self-report measures of behaviour if they surveyed participants' self-reported past, present or intended pro-environmental behaviours. Self-reports may be biased in that participants may report behaviours and intentions based on their values and ideal image of themselves. Thus, I was interested in comparing self-reports to other measures of pro-environmental behaviour. Studies that reported actual behaviours recorded in a laboratory setting were coded as using observed behavioural measures. Behaviours in laboratory settings may also be biased and subject to demand characteristics whereby participants may guess the hypothesis of the study and form conclusions about what the experimenter wants them to do. Few studies included in the

[3] Sample size had the lowest inter-rater reliability (78%), due to variation in how studies treated missing data. For studies that dropped missing cases, the sample size for the correlation between nature connection and pro-environmental behaviour was typically smaller than the overall sample reported for the study. Coders did not always catch this distinction; where applicable, the smaller sample (corresponding to the analysis of nature connection and pro-environmental behaviours) was always used.

[4] I considered measures as commonly used if they are included as measures of nature connection in at least three studies in addition to the original paper in which they were published.

meta-analysis measured suspicion among participants, so I was unable to code for demand characteristics as a possible moderator. However, for the studies included in the meta-analysis, researchers have attempted to minimize demand characteristics through study design such as embedding nature related measures within larger questionnaires, telling participants that they would be participating in two separate studies, and presenting participants with behavioural tasks in an unobtrusive way.

Studies were also coded in terms of whether they measured private or public sphere behaviours. Measures that incorporated private and public sphere types of behaviours, or that did not fit clearly into private or public sphere behaviour, were coded as 'other.' Finally, a common measurement scale for pro-environmental behaviour, the general ecological behaviour scale, (see Kaiser, 1988; Kaiser & Wilson, 2000; Kaiser & Wilson, 2004) was coded into a separate category. The general ecological behaviour (GEB) scale contains multiple subscales, some of which fit into the private-sphere behaviour category and one that fits into the public sphere behaviour category. The GEB also contains an additional subscale that measures prosocial behaviours that are not explicitly forms of pro-environmental behaviour.

Publication Status

To test for differences between published and unpublished studies, effect sizes were coded based on whether the effect size came from a published study versus an unpublished manuscript, dissertation, or raw data.

Demographics, Sample Variations, and Study Characteristics

Effect sizes were coded based on demographic sampling variations and study characteristics, specifically variation in gender ratio, age, ethnicity, country where participants were recruited, student or non-student samples, and publication. For gender, the percentage of participants reported as male and female were recorded. If only the percentage of female participants was reported, it was assumed the remaining percentage of sample was male, and vice versa. Mean age of participants was also coded. For undergraduate student samples, if mean age was not reported, it was estimated based on the mean age of other undergraduate student samples included in the meta-analysis (21.58 years). For samples that did not report mean age, but reported an age range, mean age was estimated using the midpoint of the range. As most

samples were predominantly white, (Caucasian), ethnic diversity was coded based on the percentage of participants identified as white. Country was coded based on the country where participants were recruited for the study, and eventually separated into the following most common categories: USA, Canada, European countries, China, and Other. Online studies where participants could be from multiple nationalities, or studies that recruited participants in multiple countries, were coded as 'other.' Effect sizes were coded as coming from a university student samples or from some other kind of sample. Samples that recruited university students and other sample populations were coded as 'mixed.'

3.2. Results

I conducted analyses in SPSS using meta-analysis macros created by Wilson (2011). I selected a restricted maximum likelihood (REML) estimator to estimate the error due to between-study variance within a random effects model. In general, compared to other estimators, REML estimators show less negative bias when meta-analyses include studies with large variation in sample sizes, such very large samples and very small samples (Veroniki, Jackson, Viechtbauer, Bender, Bowden, Knapp, et al., 2015). I also used an ANOVA analog and multiple regression analog for testing moderating variables that vary between studies, such as demographic variables and study characteristics.

3.2.1. Estimated Mean *r* for Total Sample

Among the full correlational sample of seventy effect sizes, there was a significant estimated effect size of $r = .41$, $p < .01$ (see Table 1). According to Cohen's guide, this falls within the range of a medium to large correlational effect size (Cohen, 1988).

3.2.2. Publication Bias

As a test of publication bias, I compared the estimated effect size of published studies to that of unpublished studies using a meta-F-test analog (Wilson, 2011). The sample contained 57 published effect sizes and 14 unpublished effect sizes. The estimated effect sizes for published studies was significant ($r = .38$, $p < .01$), as was the

estimated effect size of unpublished studies (r = .41, p < .01). There was no significant difference between the estimated effect sizes of published and unpublished studies. As an additional test for publication bias, I created a funnel plot of the sample size versus correlation coefficient r in the published correlational studies (see Figure 1). The funnel plot was symmetrical, suggesting the distribution of effect sizes in published correlational studies is what we would expect if there is no publication bias (Egger, Smith, Schneider, & Minder, 1997; Light & Pillemer, 1984).

3.2.3. Sample and Study Characteristics

I also used meta-F-test analogs and meta-regression analogs to test for potential moderation by sample and study characteristics (see Table 1 for F-test analog results and Table 2 for regression analog results). There were no significant differences in the estimated effect size based on the region in which participants had been recruited, and all regions had a significant correlation (see Table 1).

However, there was a significant difference between university student samples, non-university student samples, and mixed samples, whereby higher correlations between nature connection and pro-environmental behaviour were observed in university samples (r = .41, p < .01) compared to non-university samples (r = .34, p < .01). In addition, mixed samples reported the highest estimated effect (r = .50, p < .01), although there are only five such studies. In university and non-university samples the estimated effect size was significant, so although significantly lower than university samples, studies using non-university samples still find a significant correlation between nature connection and pro-environmental behaviour.

I tested age, gender, and ethnic diversity as potential moderators of the relationship between nature connection and pro-environmental behaviour using a multiple regression analog. I controlled for missing data by including three dichotomous variables that recorded whether information on gender, mean age, and ethnic diversity was available for each effect size. Missing values were replaced with a constant (i.e., the mean for that variable calculated from the rest of the sample).

The mean age of the sample did not moderate the correlation between nature connection and pro-environmental behaviour. Likewise, the gender ratio of the sample

(i.e., measured in the regression analog analyses as percentage of sample identifying as male) and ethnic diversity (i.e., measured as the percentage of participants identifying as white) did not moderate the relationship (see Table 2).

3.2.4. Nature Connection Measures

. Due to dependency from studies with multiple measures of nature connection, the various operationalizations of nature connection could not be statistically compared. Therefore, I conducted separate analyses to determine the estimated effect size for each commonly used measure of nature connection and emotional measures of nature connection. Effect sizes were grouped by the categories of nature connection, creating separate data sets of effect sizes to be meta-analyzed: the connection to nature scale (Mayer & Frantz, 2004), the Inclusion of Nature in the Self scale (Schultz, 2001), the Nature IAT (Schultz et al., 2004), the Environmental Identity Scale (Clayton, 2003), and emotional measures of nature connection (e.g., Perkins, 2010). I computed a mean effect size separately for each set of nature connection measures, collapsing across pro-environmental behaviours. For studies that reported multiple effect sizes within each set, I used the average of these effect sizes to represent the study. The estimated effect size for each operationalization of nature connection was significant (see Table 3). The estimated effect size for each operationalization of nature connection tended to be similar to the overall estimated effect size, with one exception. Although it cannot be tested for statistical significance, the correlation between pro-environmental behaviour and the Implicit Association Test ($r = .15$, $p < .01$) was markedly lower than correlations for other measures of nature connection that ranged from $r = .31$ to $r = .53$.

3.2.5. Pro-Environmental Behaviour Measures

As with nature connection measures, I conducted separate analyses on different operationalizations of pro-environmental behaviour. Thus, I created a set of composite effect sizes for self-report pro-environmental behaviours, observed pro-environmental behaviour, private sphere pro-environmental behaviour, public sphere pro-environmental behaviour, and the general ecological behaviour scale (Kaiser & Wilson, 2004). Once again, the differences between the mean weighted effect sizes of these operations cannot be statistically tested due to dependency. However, the estimated effect size for self-report measures and observed behavioural measures was significant. Public

sphere, private sphere and the general ecological behaviour scale had significant mean weighted effect sizes. As seen in Table 4, the correlation between nature connection and self-report behaviours (r = .43, p < .01), private sphere behaviours (r = .41, p < .01), and public sphere behaviours (r = .42, p < .01) was very similar to the overall mean weighted effect size of the full correlational dataset. The correlation between nature connection and observed behavioural measures was slightly lower (r = .21, p < .01).

Table 1. Overall estimated correlational effects with ANOVA tests of differences between publication status and sample moderators

Moderator	*r*	95% CI	*z*	*k*	Q_w	Q_b
Total	0.41**	0.37, 0.45	20.47	71	603.48**	
Publication						0.53
Published studies	0.38**	0.34, 0.42	17.54	57	45.64	
Unpublished studies	0.41**	0.34, 0.48	9.65	14	22.36	
Region						2.87
USA	0.41**	0.36, 0.46	14.63	34	39.88	
Canada	0.40**	0.31, 0.48	8.15	11	11.87	
Europe	0.35**	0.27, 0.42	8.12	14	7.78	
China	0.30*	0.11, 0.47	3.12	3	0.82	
Other	0.37**	0.27, 0.46	6.74	9	5.04	
University student sample						9.36**
Yes	0.41**	0.37, 0.46	15.55	35	41.29	
No	0.34**	0.29, 0.39	12.43	31	25.21	
Mixed	0.50**	0.39, 0.59	7.91	5	1.19	

* p < .05. ** p < .01. *k* represents number of studies. *z*-test used to test significance of mean estimated effect size. Cochrans's Q is used as a test of heterogeneity among effect sizes. A significant Q_w value suggests significant heterogeneity within a group, while a significant Q_b suggests significant differences between groups.

Table 2 Regression analog of estimated correlational effects of age, gender, and ethnic diversity

Moderator	B	95% CI	z	k	Q_{model}
Model				71	2.30
Mean Age	-0.00	-0.01, 0.002	-0.85		
Missing Age	-0.07	-0.19, 0.06	-1.05		
Model				71	1.45
% Sample Male	-0.11	-0.37, 0.16	-0.79		
Missing Gender Information	-0.06	-0.22, 0.09	-0.77		
Model				71	0.77
% Sample White	0.03	-0.24, 0.30	0.20		
Missing Ethnicity Information	-0.04	-0.12, 0.05	-0.85		

Unstandardized betas are reported. k represents number of studies. z-test used to test significance of variables in explaining variation estimated mean effect size. Cochrans's Q is used as a test of how well regression model explains heterogeneity among effect sizes.

Table 3 **Estimated correlational effect sizes for each operationalization of nature connection.**

Nature connection measure	r	95% CI	z	k	Q_w
Connection to nature scale	0.44**	0.40, 0.48	20.99	29	75.10**
Inclusion of nature in the self	0.31**	0.25, 0.37	10.60	22	104.25**
Implicit association test	0.15**	0.11, 0.20	6.60	6	4.51
Nature relatedness	0.43**	0.30, 0.56	6.67	10	64.31**
Environmental identity	0.53**	0.45, 0.61	13.37	16	84.10**
Emotional measures	0.48**	0.42, 0.55	14.57	10	38.62**

* p < .05. **p < .01. k represents number of studies. z-test used to test significance of mean estimated effect size. Cochrans's Q is used as a test of heterogeneity among effect sizes. A significant Q_w value suggests significant heterogeneity within a group.

Table 4 **Estimated correlational effect sizes for each operationalization of pro-environmental behaviour.**

Pro-environmental Behaviour	r	95% CI	z	k	Q_w
Self-report scales	0.43**	0.39, 0.47	20.04	67	639.57**
Observed behaviours	0.21**	0.15, 0.27	7.07	6	0.51
Private sphere behaviours	0.41**	0.35, 0.48	12.84	37	359.68**
Public sphere behaviours	0.42**	0.33, 0.51	9.20	13	163.39**
General ecological behaviour	0.44**	0.36, 0.51	11.47	8	24.13*

* p < .05, ** p < .01. k represents number of studies. z-test used to test significance of mean estimated effect size. Cochrans's Q is used as a test of heterogeneity among effect sizes. A significant Q_w value suggests significant heterogeneity within a group.

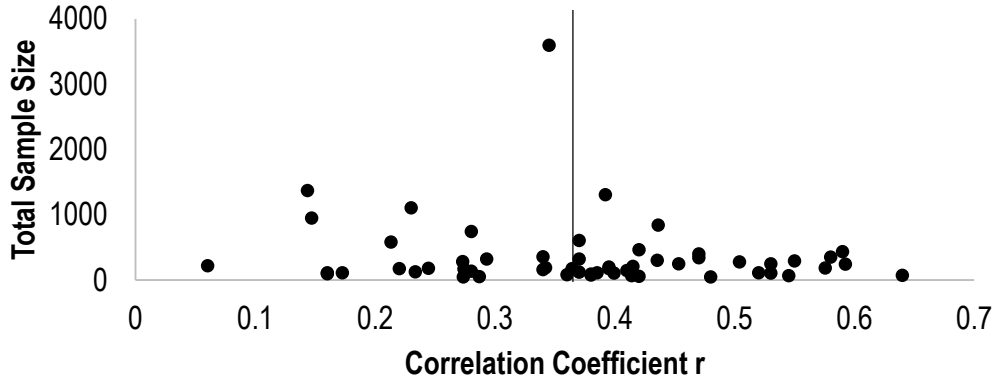

Figure 1 **Funnel plot of published correlational studies. Line represents estimated effect size of the published correlational studies (r = .38).**

3.3. Discussion

One purpose of the correlational meta-analysis was to determine the strength of the relationship between nature connection and pro-environmental behaviour. I found a

large association between nature connection and pro-environmental behaviour. The strength of this correlation is comparable to the strength of association between pro-environmental behaviour and other key predictors of pro-environmental behaviour that have been examined in past reviews (Bamberg & Möser, 2007). Furthermore, I found no evidence of publication bias for correlational studies when comparing published and unpublished data. Thus, the results on the correlation between nature connection and pro-environmental behaviour in the published literature are likely an accurate estimate of this relationship. Furthermore, the correlation between nature connection and pro-environmental behaviours appears to be robust across tests of different potential moderators. Gender, age, ethnic diversity, and country did not significantly moderate the strength of the relationship between nature connection and pro-environmental behaviours. Thus, the sample characteristics that I could examine in these data did not change the strength of the relationship between nature connection and pro-environmental behaviour.

Significant differences in the overall strength of the relationship between university student samples and non-university samples did emerge. These differences suggest that studies examining the relationship between nature connection using convenience samples of undergraduate students could be finding inflated effects. An explanation for this is that undergraduate students may be more familiar with answering the survey questions used in nature connection and pro-environmental behaviour studies, and thus answer more accurately. It is possible as well that, in the context of environmental issues, university students may be more likely to act in ways consistent with their attitudes. However, the correlation among non-university samples is also significant, if smaller, than university student samples. Thus, the relationship is not limited to university samples but exists more broadly within the general population.

When testing the relationship between pro-environmental behaviours and different operationalizations of nature connection separately, significant associations emerged between each of the operationalizations of nature connection I considered and pro-environmental behaviour. Although differences between various operationalizations of nature connection could not be tested in this analysis, some correlations between these variables were descriptively smaller than others. The nature Implicit Association Test (IAT) as a measure of nature connection had a much smaller correlation with pro-environmental behaviour than other nature connection measures. Indeed, implicit

measures of nature connection often correlate poorly with explicit measures of behaviour (Geng et al., 2015). Thus, the relatively low correlation between the IAT and pro-environmental behaviours relative to other measures of nature connection could be due to implicit and explicit measures capturing different psychological processes.

As with nature connection, I examined different operationalizations of pro-environmental behaviour separately. There was a significant relationship between nature connection and self-reports of behaviour, private sphere behaviours, and public sphere behaviours. Although smaller than for other types of pro-environmental behaviour measures, observed behaviour was also significantly related to nature connection. Given that observed behavioural measures are a more accurate reflection of pro-environmental behaviour (Kormos & Gifford, 2014), these results provide compelling evidence that nature connection predicts actual behaviour, not just self-reports and behavioural intentions.

Chapter 4.

Experimental Meta-Analysis

I next conducted a meta-analysis on experimental effect sizes to determine whether causal evidence exists to suggest that feeling psychologically connected to nature leads individuals to take pro-environmental actions.

4.1. Methods

For experimental studies, effect size was measured using Cohen's d. I estimated d across the experimental studies identified in the literature that met the inclusion criteria. I used reported means and standard deviations to compute standardized mean difference (d) values. If studies did not report the necessary means and standard deviations of the control and treatment groups, I used other available statistics to calculate d scores such as t, F, and chi square statistics. If there was not enough information to calculate d and authors could not be contacted or were unable to respond with the necessary information, studies were excluded.

4.1.1. Coding Procedure

For the experimental studies, my supervisor and I coded each study. Inter-rater reliability was high, between 76-100% with an average reliability of 93%. Coders met to resolve discrepancies.

Nature Connection Manipulation

Manipulations of nature connection were coded into four categories depending on whether participants were assigned to view images or videos of nature, to reflect on the ways in which they felt connected to nature, or to answer questions asking them to categorize themselves as part of nature. In addition to coding how nature connection was manipulated, the success of the manipulation was coded based on manipulation checks reported in the study. If the manipulation had a significant or marginal (i.e., $p < .10$) effect on a measure of nature connection, this was coded as a successful manipulation (even if other measures of nature connection were not significantly affected

by condition). If a manipulation had a non-significant effect on a measure of nature connection, it was coded as unsuccessful, and if no manipulation check was reported this was coded as having no manipulation check.

Pro-Environmental Behaviour

Pro-environmental behaviours were coded as in the correlational data set. Some samples in the experimental meta-analysis included multiple measures of pro-environmental behaviour. As such, I computed composite effect sizes (i.e., Cohen's d) for all experimental studies with multiple effect sizes. Thus, studies with multiple effect sizes were represented by the average of those effect sizes. Composite effect sizes were also computed for studies based on types of pro-environmental behaviour measures.

Other Variables

Publication status, gender, mean age, ethnicity, country, and university versus non-university student samples were all coded as in the correlational meta-analysis.

4.2. Results

The total experimental dataset included twelve effect sizes (see Appendix C for full list of studies).

4.2.1. Estimated Mean *d* for Total Sample

As seen in Table 5, the estimated effect size for the total sample of twelve experimental studies was significant (d = .25, p = .01).

4.2.2. Publication Bias

The estimated effect size differed significantly between published and unpublished studies (see Table 5). Published studies had a significant estimated effect size (d = .41, p < .01), while the estimated effect size among unpublished studies was non-significant (d = .07, p = .48). I created a funnel plot of the sample size and effect sizes in published studies (see Figure 2). This plot showed asymmetry, with "missing" effect sizes to the left side of the funnel, suggesting a publication bias against studies

with very small and non-significant effect sizes. I created a second funnel plot including the unpublished effect sizes, and that appears more symmetrical, with the unpublished effect sizes filling in the gap.

4.2.3. Manipulation Check

There were significant differences among studies that reported a successful manipulation check, studies that reported an unsuccessful manipulation check, and studies that did not report a manipulation check (see Table 5). Studies that reported a significant manipulation check had a small but significant estimated effect size comparable to that found in the overall sample (d = 0.26, p = .01). Surprisingly, studies that reported an unsuccessful manipulation of nature connection also had a significant estimated effect size (d = .51, p < .01). Studies that did not report a manipulation check did not have a significant estimated effect size (d = -.07, p = .48).

4.2.4. Pro-Environmental Behaviour

I separately examined various operationalizations of pro-environmental behaviour (see Table 6). The estimate of the effect size for the relationship between self-report behaviours and nature connection was significant (d = .26, p <.01). However, the estimate of the effect size of observed behaviours was non-significant. The estimate of the effect size for public sphere behaviours was also significant but for private sphere behaviours was non-significant.

Looking more closely at the experimental studies measuring observed behaviour, there is one potential outlier. Capaldi (2014) showed videos of nature or control videos unrelated to nature to participants, but found that the videos differed on ratings of pleasantness. The control videos predicted greater observed pro-environmental behaviours than the nature videos, however this effect became non-significant when statistically controlling for ratings of pleasantness (Capaldi, 2014). As the manipulation in this study may be affecting other factors besides nature connection, I ran a second set of analyses excluding the effect size from Capaldi (2014). With this outlier excluded,

there was a significant effect of nature connection on observed behaviours (d = .32, p < .01). The results did not change for self-report and public sphere behaviours.[5]

Table 5 Overall estimated experimental effect size with ANOVA analog tests of publication bias, manipulation check and type of manipulation

Moderator	d	95% CI	z	k	Q_w	Q_b
Total	0.25**	0.07, 0.43	2.71	12	28.08**	
Publication						5.97*
Published	0.42**	0.22, 0.62	4.14	6	4.77	
Unpublished	0.07	-0.12, 0.27	0.71	6	7.43	
Manipulation Check		0.10, 0.42				15.85**
Significant	0.26*	0.30 0.72	3.15	5	6.66	
Non-Significant	0.51**	-0.27, 0.13	4.79	3	1.71	
Not reported	-0.07		-0.70	4	3.86	

* p < .05. ** p < .01. k represents number of studies. z-test used to test significance of mean estimated effect size. Cochrans's Q is used as a test of heterogeneity among effect sizes. A significant Q_w value suggests significant heterogeneity within a group, while a significant Q_b suggests significant differences between groups.

Table 6 Estimated experimental effect sizes for each operationalization of pro-environmental behaviour.

Behaviour	d	95% CI	z	k	Q_w
Self-Report	0.26*	0.04, 0.50	2.27	6	10.32
Observed Behaviours	0.15	-0.18, 0.47	0.87	5	12.74*
Private Sphere	-0.025	-0.55, 0.04	-1.69	2	0.28*
Public Sphere	0.34**	0.12, 0.55	3.08	4	3.15

* p < .05. ** p < .01. k represents number of studies. z-test used to test significance of mean estimated effect size. Cochrans's Q is used as a test of heterogeneity among effect sizes. A significant Q_w value suggests significant heterogeneity within a group.

[5] When Capaldi (2014) is excluded from analyses, the overall estimated mean effect size remains small but significant (d = .31). The results of other analyses similarly do not change in direction, magnitude, or significance (see Appendix D).

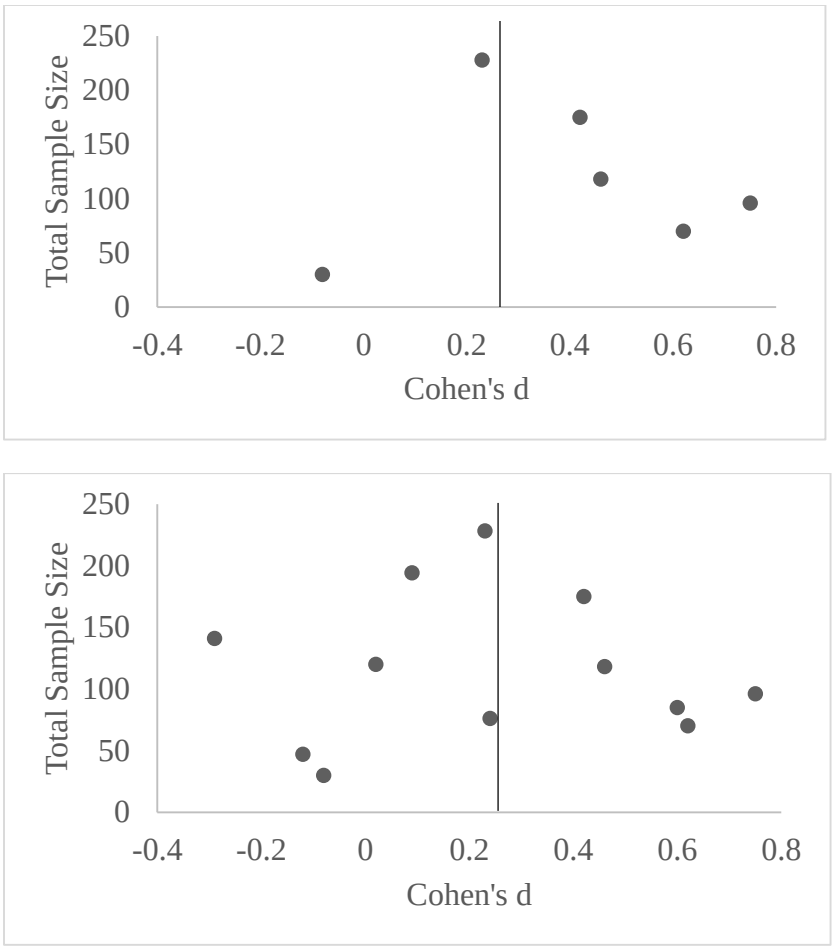

Figure 2 **Funnel plots of experimental studies. The top panel represents published experimental studies only. The bottom panel represents published and unpublished experimental studies. Line represents estimated effect size for total sample of published and unpublished effect sizes (d = .25).**

4.3. Discussion

In the experimental meta-analysis, I examined causal evidence that nature connection leads to pro-environmental behaviour and found that there is evidence for causal relationship between nature connection and pro-environmental behaviour. Furthermore, the experimental meta-analysis provides a valuable contribution by testing for publication bias, as previous reviews of the literature have not included unpublished data. Published data produced a significantly higher estimated effect size than unpublished data, and overall the estimated effect size of unpublished data was non-significant. These results provide evidence that a publication bias exists among literature examining causal effects of nature connection on pro-environmental behaviour.

As such, the published literature tends to overestimate the strength of effects. However, by including unpublished data in the meta-analysis, I was able to correct for this bias when estimating the causal effect size, and still found a small significant effect of nature connection on pro-environmental behaviour. Thus there is still compelling evidence for a causal effect.

In the overall experimental data are several studies that did not report evidence that the experimental manipulation was successful. Many studies that did not report manipulation checks were unpublished, thus it could be that publication is confounded with the quality of the study, such that unpublished data has remained unpublished due to methodological issues (i.e., failure to include a manipulation check). However, this meta-analysis included studies that had been published despite including a manipulation check that did not find evidence the manipulation succeeded. In such studies, the manipulation tended to have quite a large effect on pro-environmental behaviour. Thus, it may well be the case that studies with large rather than small effect sizes tend to be published regardless of evidence that the manipulation worked as intended. These results are in keeping with the finding of a file drawer effect.

Counterintuitively, studies that did not find evidence the manipulation affected nature connection (i.e. failed manipulation check) nonetheless showed the highest effects of the manipulation on pro-environmental behaviour. One possible explanation could be that experimental manipulations of nature connection impact connection to nature in more subtle ways than measures of nature connection are able to capture. However, it is also worth noting that only three studies fell into this category of finding an effect on the manipulation on behaviour but not on nature connection, and two of these studies were conducted by the same research lab. Therefore, it is possible these findings are idiosyncratic to these studies.

Although nature connection had a significant estimated effect on self-report measures and public sphere behaviours, there were not significant effects for observed behaviours and private sphere behaviours. However, due to the small number of experimental studies included in this analysis, it is difficult to interpret whether differences between the effects found for the types of pro-environmental behaviours are meaningful. Furthermore, at least one of the studies included in the private sphere and observed behaviour groups reported issues with the manipulation of nature connection,

where the manipulation may not have worked as intended and found a significant negative relationship between nature connection and pro-environmental behaviours (Capaldi, 2014). Thus, it is possible that this study represents an outlier that has a strong effect on the results given the small number of studies. When this potential outlier is excluded, there was a significant causal relationship found between nature connection and observed pro-environmental behaviours. Thus, the experimental evidence does find some evidence that nature connection can affect actual behaviour, rather than just self-reports. Additionally, due to the small number of studies there was not enough variation to meaningfully test moderators such as age, gender, ethnic diversity, country where data was collected, and university versus non-university student samples.

In sum, the results of the experimental meta-analysis do show evidence that nature connection has a causal effect on pro-environmental behaviour. Specifically, there is a small but significant effect size observed among the overall sample of experimental studies, and this effect remains significant when restricted to studies that reported evidence of a successful manipulation of nature connection.

Chapter 5.

General Discussion

In sum, the results of this meta-analysis provide good evidence for a relationship between nature connection and pro-environmental behaviour. Among the correlational data, there is a strong association between nature connection and pro-environmental action (r = .41). For comparison, this association is comparable to those observed by Bamberg and Möser (2007) between pro-environmental behaviour and attitudes (r = .42) and pro-environmental behaviour and moral norms (r = .39), social norms (r = .31) and guilt (r = .30). Thus, the relationship between nature connection and pro-environmental behaviour is of similar strength to some of the strongest associations found between other variables and pro-environmental behaviour. In addition, the estimated correlational relationship is similar in published and unpublished studies. Therefore, the effects observed in published literature are likely an accurate reflection of the relationship that exists, and are not over-estimating the correlation between nature connection and pro-environmental behaviour.

I also estimated the relationship for operationalizations of nature connection, and all the commonly used measures of nature connection included in this meta-analysis were correlated with pro-environmental behaviour. However, there may be some differences in how strongly different measures of nature connection relate to pro-environmental behaviour. The Inclusion of Nature in the Self Scale and the Nature IAT showed lower correlations with pro-environmental behaviour than other measures of nature connection.

I estimated the correlation between nature connection and different types of pro-environmental behavior, and found nature connection is correlated with self-report and observed behaviours, and with private and public sphere behaviours. Thus, I addressed concerns about the accuracy of self-report measures (Kormos & Gifford, 2014) by showing that the relationship exists when examining nature connection's association with behaviours that have been directly observed by researchers. In addition, this meta-analysis provides evidence that nature connection is related to a wide range of pro-environmental behaviours, from private sphere behaviours such as recycling, to public

sphere actions such as protesting environmentally damaging projects. Furthermore, based on the results of the correlational meta-analysis, the association between nature connection and pro-environmental behaviour does not appear to be associated with sample characteristics such as age, gender, ethnic diversity, and nationality. For studies in this sample, the correlation between nature connection and pro-environmental behaviour is generalizable across these demographic factors.

Finally, I examined whether nature connection causes pro-environmental behaviour in the meta-analysis on experimental data, and there was a small but significant causal effect (d = .25). Contrary to the correlational meta-analysis there was evidence of publication bias; in general, the unpublished studies included in the analysis did not demonstrate significant causal effects. By including an equal number of unpublished studies as published studies, I corrected for the bias toward larger effect sizes in published studies. Despite the higher number of null effects among unpublished data compared to published studies, a significant causal effect was still observed with the inclusion of the unpublished data. Thus, even with the inclusion of unpublished findings, the results of the experimental meta-analysis still show evidence that nature connection causes pro-environmental behaviour.

5.1. Discrepancies Between Correlational and Experimental Findings

The causal effects in the experimental meta-analysis are weaker than one might expect given the relatively large effect sizes in the correlational data. A possible explanation for this difference is a discrepancy between how nature connection is measured and how it is manipulated. Nature connection is conceptualized in this meta-analysis and by many researchers as a sense of oneness with the natural world, where oneness involves the inclusion of nature in one's sense of self (Mayer & Frantz, 2004; Schultz, 2001). As such, nature connection can be thought of as a form of identity (Schmitt et al., 2014). Many measures of nature connection attempt to capture this sense of identification through items such as "I think of the natural world as a community to which I belong" (Mayer & Frantz, 2004) and "Being a part of the ecosystem is an important part of who I am" (Clayton, 2003). However, experimental manipulations of nature connection often do not manipulate identity, but rather a sense of connection that may arise from contact with nature.

Many early experiments on nature connection were designed to test the impact of contact with nature on health and well-being (Capaldi et al., 2014). Researchers have been able to demonstrate that even limited contact with nature, such as exposure to images and videos of nature, can have positive health benefits (Capaldi et al., 2014; Kahn, Severson, & Ruckert, 2009). Although a few minutes of contact with nature has been shown to increase connection to nature in some cases (see Scott, 2010), in many contexts brief contact with nature may not be a strong enough manipulation to create a sense of oneness with nature. It may be the case that attempts to experimentally manipulate nature connection are unable to create a sense of connection to nature that reflects a deep sense of identity and oneness that fully captures nature connection. As such, experimental studies may produce smaller effect sizes than one would expect from the strong correlation between nature connection and pro-environmental behaviour because correlational measures have been better able to tap into the psychological construct of nature connection than experimental manipulations.

Given that nature connection involves incorporating nature into one's self-definition, changes to how one sees oneself may be a longer, more complicated process than experimental lab studies are able to capture within an hour or a day. All of the experimental studies included in the meta-analysis were lab studies that occurred over a very short time frame of twenty to sixty minutes. The influence of nature connection on pro-environmental behaviour may be better observed over a long-term context, such as weeks or months, rather than in short-term experimental lab studies. It may take time to develop a strong sense of oneness with nature, as such experimental studies attempting to manipulate nature connection within an hour may only be getting participants started on this process.

5.2. Limitations and Future Directions

Due to dependency caused by studies with multiple effect sizes, I was not able to statistically compare differences between different operationalizations of nature connection and pro-environmental behaviour measures. Other techniques exist to account for dependency while retaining the ability to statistically compare effect sizes from multiple studies. Future studies could tease apart conceptual differences in how nature connection has been operationalized to gain insight into the psychological process by which nature connection facilitates pro-environmental behaviour.

Given that nature connection likely takes time to develop, future research could benefit from using long-term interventions to manipulate nature connection. For example, researchers have developed interventions to get participants to think about the ways in which they feel connected to nature lasting over several weeks (see Collado, Staats, & Corraliza, 2013; Passmore & Holder, 2017; Richardson, Cormack, Robert, & Underhill, 2016). With experimental interventions aimed at changing nature connection over a longer period of time, future research may be able to manipulate nature connection more effectively and see more pronounced effects on pro-environmental behaviour. Furthermore, it is possible that nature connection indirectly causes pro-environmental behaviour by activating other psychological processes that lead to pro-environmental action. Several processes have been theorized to facilitate the relationship between nature connection and pro-environmental action, such as empathy (McIntyre, 2012), moral responsibility (Schmitt et al., 2014), and identification with politicized activist groups (Schmitt et al., 2014). Very few studies have examined potential processes that mediate the relationship between nature connection and pro-environmental action. As such, future research could address this gap by incorporating potential mediating processes. Future research should also consider that nature connection and any psychological processes flowing from it likely take time to influence pro-environmental behaviour. The correlational meta-analysis included only cross-sectional results. I did not include longitudinal or repeated measures results due to the small number of studies in the literature examining nature connection's relationship with pro-environmental behaviour over time. The findings of these studies have been mixed (Unanue et al., 2016; Veijalainen and Clayton, 2013). As such, more longitudinal research is also needed to track the effect of nature connection on pro-environmental behaviour across time.

The majority of studies included in this meta-analysis were conducted in western, industrialized nations. All of the experimental studies were conducted on university students. As such, future research conducted on more diverse samples would be beneficial in determining whether the relationship between nature connection and pro-environmental behaviour is generalizable across different populations. There may well be cross-cultural differences in how oneness with nature is perceived in relation to environmental stewardship and the influence such an identity has on pro-environmental action. For example, indigenous communities may have different relationships to their

traditional land and understandings of responsibility towards taking care of it than non-indigenous peoples (Nadasdy, 2005). Furthermore, I was not able to include other potential moderators such as socio-economic status, due to the small number of studies that measured this variable. Individuals and communities with low socio-economic status tend to be disproportionately located near damaged environments and exposed to health risks as a result (Boyce, 2007; Jackson, 2011). Thus, those with low socio-economic status may see environmental harm as both more personally relevant and requiring urgent attention compared with individuals who have the economic resources to avoid the negative impacts of environmental destruction. Future research could further explore these ideas and other potential moderators of the relationship between nature connection and pro-environmental behaviour.

5.3. Implications for Policy and Intervention

Given the strong correlation between nature connection and pro-environmental behaviours, and evidence that nature connection does lead to pro-environmental action, policies and interventions aimed at promoting pro-environmental action could benefit from targeting nature connection. Because of the lack of natural settings in cities, individuals living in urban environments are often disconnected from nature (Capaldi et al., 2014). Being disconnected from nature may have negative consequences for pro-environmental action. Thus, urban planning and programs that incorporate nature into urban environments and increase awareness of the natural world and feelings of connection with nature could promote pro-environmental action.

However, caution should be taken in developing such interventions to make sure they are able to manipulate a sense of oneness with nature. Interventions that bring people into contact with nature for a short period of time may not create enough of a sense of connection to nature in individuals to influence pro-environmental action. More successful interventions would encourage participants to not only spend time in nature, but also to reflect on the ways in which they feel like a part of nature (see Passmore & Holder, 2017; Richardson et al., 2016 for examples). Developing such interventions may also provide a rich context for future research aiming to examine the processes by which nature connection impacts behaviour over time. By monitoring the effects of increased nature connection on people's pro-environmental action in the long term, we may gain a

better understanding of how nature connection develops and leads to pro-environmental behaviour.

5.4. Conclusion

In summary, the results of this meta-analysis contribute to the body of evidence that nature connection is related to pro-environmental action. By including published and unpublished data, I was able to consider the possibility of a file-drawer-effect and show evidence the relationship observed in published literature is not an artefact of publication bias. Furthermore, I conducted a meta-analysis on experimental studies as an empirical test of whether nature connection causes pro-environmental behaviour, and found evidence for a small causal effect. Together, the results of meta-analyses of correlational and experimental studies provide compelling evidence that connecting people with nature may be a promising avenue for promoting action to protect the environment and prevent harm to nature.

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Appendix A.

Search Terms

Table A1. Search terms used to gather records from online data bases

Variable	Search Terms
Nature Connection	Nature connection, connection to nature, nature connectedness, connectedness to nature, connection with nature, connection to the natural world, connectedness with nature, connection with the natural world, inclusion of nature in the self, nature included in the self, environmental identity, identification with the environment, identification with the natural world, identification with the biosphere, biospheric identity, nature identity, natural world identity, environmental self-identity, nature relatedness, relationship with nature, human-nature relationship, relationship with the natural world, emotional affinity toward nature, emotional affinity for nature, love and care for nature, emotional attachment to nature
Pro-environmental Behaviour	Pro-environmental behavior, pro-environmental action, environmentally responsible behavior, ecologically responsible behavior, environmentally friendly behavior, sustainable behavior, sustainable action, environmental action, pro-environmental collective action, environmental activism, support for environmental policy, environmental policy support, environmental stewardship, conservation behavior

Pro-environmental behaviour search terms included two variant spellings, behaviour and behavior. The search string also included the phrase “not qualitative” in order to rule out studies that were unlikely to contain the data necessary for meta-analysis.

Appendix B.

Coding Instructions

All Studies

Publication status: Enter the corresponding code to indicate whether the effect size is from a published paper, a dissertation, or an unpublished manuscript/dataset.

1. Published
2. Dissertation
3. Unpublished manuscript/data set (not a dissertation)

N: Enter the sample size that corresponds to the effect size. Many studies report sample size in the abstract, in beginning of the Methods section, or in the beginning of the Results section. However, you may also need to double-check the correlation table or the place where the effect size is reported (highlighted), as sometimes the entire study sample is not used for the correlation analysis.

% female: Enter the percentage of the sample that is reported as female. If the number of females is reported rather than the percent (e.g., 203 out of a sample of 300) then calculate the percentage from the total: number of females/total sample size x 10. E.g. (203/300=.68)*10=68%.

% male: Enter the percentage of the sample that is reported as male, see also instructions for %female.

Age M: Enter the mean age of participants in the sample.

% white: Enter the percentage of the sample ethnically identified as white. See also instructions for % female if the number of white participants is reported rather than the percentage.

Notes on other ethnicities: List any other ethnicities included in the sample and the percentage of the sample each group makes up. See also instructions for % female if numbers of participants are reported rather than percentage.

Country: Enter the country where the participants were recruited.

Sample Code: Enter the corresponding code for the type of sample population that was recruited.

1. University students (can include both undergraduate and graduate students)

2. Representative sample of adults, attempts to survey wide variety of people (e.g., mTurk survey, mail survey, pedestrians or citizens recruited from city)

3. Specific groups that may not be representative of broader population (e.g., farmers, landowners, children/youth/minors, tourists, activist organizations)

4. Mixed: participants recruited in ways that fit into more than one of the above categories (e.g., recruited university students and surveyed mTurk participants, recruited general sample of adults and targeted environmental organizations, etc.)

Sample Notes: Any notes about specific subpopulations sampled, or ambiguity in how the sample demographics were reported.

PEB measurement: Enter the corresponding code for how pro-environmental behaviours were measured in the study.

SR Self-report measures of pro-environmental behaviour (where participant fills out survey or answers questions about their own behaviour)

OB Observed behavioural measure (e.g., during study, researchers observe whether participants place scrap paper in a recycling bin or trash)

OTH Another way of measuring PEBs that do not fit into the above categories

PEB type: Enter the corresponding code for the types of pro-environmental behaviours that are being measured in the study.

1. Private sphere/individual behaviours: Behaviours aimed at reducing one's own environmental impact. This can include:

    - Behaviours related to conserving natural areas and habitats for other species (planting trees, signing legal conservation agreements as a landowner, etc.)

    - Purchasing 'green' or environmentally friendly products, or choosing such products over others when given the option

    - Reducing one's consumption of material goods (e.g., re-using containers, making a conscious effort to purchase less, etc.)

    - Reducing energy use (e.g., through household energy saving programs, taking more energy-efficient transportation, etc.)

    - Reducing water use (e.g., shorter showers)

    - Reducing food waste (e.g., adopting a more eco-friendly diet, composting)

    - Recycling

2. Public sphere/social change behaviours: behaviours aimed at reducing collective environmental impact or creating social change. This can include:

        - Behaviours that describe boycotting companies and products that are not environmentally friendly. Items should use the word boycotting/boycott or describe the not purchasing behaviour as a way of sending a message or punishing companies. Items that only say 'avoid purchasing harmful products' should be coded as private-sphere, not public-sphere.

        - Involvement with pro-environmental groups or organizations (e.g., are you a member of an environmental group, would you join a group dedicated to protecting the environment). Also includes

measures where participants are asked if they support an environmental group's efforts or support groups financially through donations.

- Behaviours related to democratic process (e.g., asking people whether they would vote for 'green' candidates, vote for environmental policies, sign environmental petitions, etc.)

- Participation in the environmental movement or environmental activism behaviours (e.g., participating in blockades, rallies, demonstrations, whether participants consider themselves part of the environmental movement)

- Behaviours aimed at influencing and educating others, such as when participants are asked about whether they try to educate others about environmental issues, whether they talk to friends and family about environmental issues, whether they encourage others in their life to engage in pro-environmental behaviours, etc.

3. Other: Behaviours described do not fit clearly into private sphere or public sphere behaviours (e.g., behavior during a game designed for lab study); OR, PEB scale or measure contains a mix of public sphere and private sphere items

4. The General Ecological Behaviour Scale (GEB): The general ecological behavior scale is a commonly used measure of pro-environmental behavior and has its own category for our coding purposes. It was developed by Kaiser & Wilson (2004), therefore these authors should usually be cited by studies that use the scale. If the scale is simply called 'ecological behaviour' and Kaiser & Wilson are not cited then it is not the GEB.

PEB Notes: Can use this section to briefly describe/name the PEB scales used or the types of behaviours (conservation, etc.) included. Also make note of any points of confusion or uncertainty while coding pro-environmental behaviours.

Correlational Studies

Effect size: The observed Pearson correlation coefficient, *r*, between a measure of nature connection and a measure of pro-environmental behaviour included in the study.

NC Variable: Enter the corresponding code for the nature connection variable used in the study.

CNS	Connection to nature scale (Mayer & Frantz, 2003)
INS	Inclusion of nature in the self scale (Shultz, 2001)
IAT	Implicit association with nature test (Schultz et al. 2004)
NR	Nature relatedness scale (Nisbet et al. 2009)
EID	Environmental identity scale (Clayton, 2003)
EM	A measure of emotional connection to nature (e.g., emotional affinity toward nature, love and care for nature scale; look for items in scale that talk about feeling good in nature)
OTH	Any other measure of nature connection that does not fit into the above categories

NC Notes: If any other nature connection variables are used, please briefly name them. Can also use this space to briefly describe/name emotional measures used or indicate if sub-sets/alterations to other scales were used (e.g., edited CNS scale created for use with children).

Experimental Studies

Effect size: Cohen's d of difference between nature connection and control/comparison groups. If Cohen's d not reported in study record following information if available: means and standard deviations of nature connection and control/comparison groups, OR t statistic, OR F statistic, OR chi-square statistic.

NC Manip: Enter the corresponding code for the type of nature connection manipulation used in the study and any control or other conditions.

PE	Physical exposure to natural setting (e.g., walk in park) vs. exposure to built/man-made setting (e.g., walk indoors)
EE/PE	Environmental education program that includes physical exposure to natural setting (e.g., learning outdoors)
AE	Artificial exposure to natural settings (e.g., pictures of nature) vs. exposure to built/man-made setting (e.g., pictures of city)
RF	Participants asked to reflect by writing or thinking about ways they are connected to nature vs. ways they are disconnected or unrelated control
ID	Indirect or unobtrusive manipulation of nature connection (so that participants are unlikely to be aware or guess that they are meant to be thinking of the natural world)
EE	Environmental education program
OTH	Any other methods of manipulating nature connection that do not fit into the above categories (or mix of above categories).

Manip Notes: If other methods of manipulating nature connection are used please describe them. Can also use this section to record any notes about the manipulation used in the study.

Manipulation Check ES: Enter the effect size (d) of any manipulation check tests (whether nature connection differs between conditions). If there are multiple manipulation check tests, enter the ES that corresponds to CNS.

Check: Enter corresponding code to indicate whether nature connection is reported to significantly differ between conditions in study as expected. Use the results for CNS if there are multiple manipulation check tests.

1. Nature connection differs significantly between conditions in expected direction

2. Marginal results in expected direction

3. Nature connection does not significantly differ between studies or differs significantly in the opposite direction than expected

4. Manipulation check indicate significant effect on NC in the opposite direction than predicted

5. No manipulation check was reported in the study

Appendix C.

Studies Included in Experimental Meta-Analysis

Table C1. Experimental studies included in meta-analysis.

Study	N	Manipulation	Manipulation Success	Pub.	ES
Arendt & Matthes (2014)	175	Participants watched documentary on nature or documentary on theory of relativity.	Condition had no significant impact on INS (d=.08) or IAT (d=-.03)	Y	.42
Capaldi (2014) [Study 2]	141	Participants viewed slideshow of photographs about nature or about urban environments.	No manipulation check	N	-.29
Davis, Green, & Reed (2009) [Study 2]	70	Participants answered questions about ways they were connected to the natural world or ways they were not connected to the natural world.	Condition had marginal impact on commitment to nature scale (d=.43).	Y	.62
Pensini (2017) [Study 1]	120	Participants completed self-categorization tasks, categorizing self as part of nature was included in one condition and not the other.	No manipulation check	N	.02
Pensini (2017) [Study 2]	194	Participants asked to categorize themselves as part of nature or part of humanity.	Condition had significant impact on INS (d=.26) but not CNS (d=.08).	N	.09
Schade, van der Waal, Krabbendam, & van Vugt (2012) [Study 1]	76	Participants looked at pictures of natural environments or city environments.	No manipulation check	N	.24
Schade et al. (2012) [Study 2]	47	Participants looked at pictures of natural environments or city environments.	No manipulation check	N	-.12
Scott (2010) [Study 3]	30	Participants sit in room with window providing view outdoors and plants present and printed picture of sunflower, or in same room with windows closed, no plants, and abstract prints.[1]	Condition had significant impact on INS (d=.33), but not CNS (d=.04)	Y	-.08

Wirthgen & Pensini (2017)	85	Participants asked to imagine a journey through nature or to imagine a journey through an urban environment.[2]	Condition had marginal impact on CNS (d=.12) and significant impact on INS (d=.71)	N	.60
Zelenski, Dopko, & Capaldi (2015) [Study 1]	96	Participants watched documentary about nature or control video about urban environments.	Condition had no significant impact on INS (d=.18)	Y	.75
Zelenski et al., (2015) [Study 2]	118	Participants watched documentary about nature or control video unrelated to nature.[3]	Condition had no significant effect on INS (d=-.06).	Y	.46
Zelenski et al., (2015) [Study 3]	228	Participants viewed videos of nature or videos of urban environments.[4]	Condition had a marginal impact on INS (d=.28)	Y	.23

[1] Study included four conditions (total N=60), however only two conditions (exposure to nature and control) were coded as relevant to the meta-analysis, therefore the other two (objectification of women and women in nature) were excluded.

[2] Study had four conditions in a 2x2 design, participants were asked to take the perspective of someone else when imagining the journey or control. For the meta-analysis perspective-taking was ignored and means were pooled for the two nature journey conditions and for the two non-nature journey conditions when calculating the effect size.

[3] Study had three conditions, one documentary on nature and two controls (documentary on architecture and podcast about grammar), means for control conditions were pooled when calculating effect size.

[4] Study included five conditions: two unpleasant nature videos (natural disasters and dangerous predators), one pleasant nature video, one unpleasant urban environment and one pleasant urban environment. In calculating a single effect size for the meta-analysis, the means for the three nature conditions were pooled for the experimental condition and the two means for the urban environments were pooled for the control condition.

Appendix D.

Supplementary Analyses

Table D1. Overall estimated experimental effect size with ANOVA analog tests of publication bias, manipulation check and type of manipulation without outlier

Moderator	*d*	95% CI	*z*	*k*	Q_w	Q_b
Total	0.31**	0.15, 0.46	3.87	11	16.94	
Publication						4.36*
Published	0.42**	0.25, 0.55	5.18	6	6.95	
Unpublished	0.16	-0.02, 0.33	1.77	5	5.63	
Manipulation Check						7.52*
Significant	0.26**	0.10, 0.42	3.15	5	6.66	
Non-Significant	0.51**	0.30 0.72	4.79	3	1.71	
Not reported	0.06	-0.19, 0.31	0.48	3	1.05	

* $p < .05$. ** $p < .01$. *k* represents number of studies. *z*-test used to test significance of mean estimated effect size. Cochrans's Q is used as a test of heterogeneity among effect sizes. A significant Q_w value suggests significant heterogeneity within a group, while a significant Q_b suggests significant differences between groups.